august, 1960

nlgi spokesman

journal of the national lubricating grease institute

Review of Research Studies Showing Need for a Viscosity Test Below 1 Sec.$^{-1}$

By E. L. ARMSTRONG

Spotlighting Our Dispensing Problems

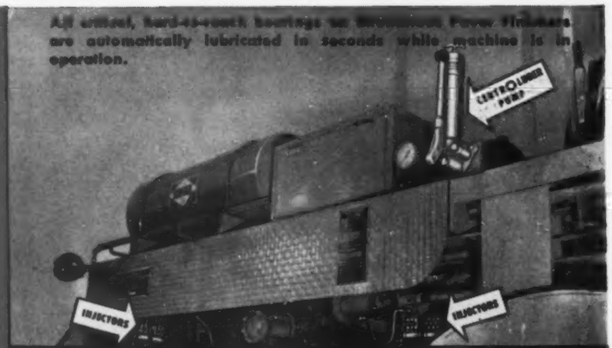
By L. C. BRUNSTRUM

New Thickener System Extends Range of Multi-Purpose Greases

By J. J. KOLFENBACH and A. J. MORWAY

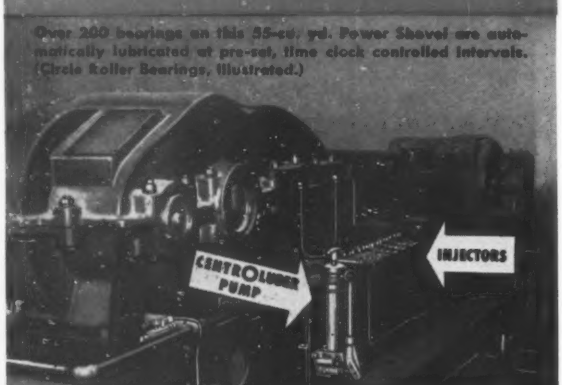
Heavy equipment lasts longer, produces more with . . .

LINCOLN POWER LUBRICATION SYSTEMS



All critical, hard-to-reach bearings on [illegible] Power Finishers are automatically lubricated in seconds while machine is in operation.

Hydraulic centralized lubrication system lubricates 68 bearings automatically on Coal Loaders. System cycles at pre-arranged number of movements of the loading head.



Over 200 bearings on this 55-cu. yd. Power Shovel are automatically lubricated at pre-set, time clock controlled intervals. (Circle Roller Bearings, illustrated.)

All lubrication points on this overhead Crane are automatically lubricated in 10 seconds with five strokes of the lubricant pump handle.

With new equipment costs at an all-time high and depreciation allowances brutally low, you need and want longer, more productive machine life in your plant.

Progressive manufacturers of many types of heavy-duty machinery and equipment are extending service-life, eliminating downtime for lubrication and cutting operating costs by installing Lincoln Power Lubrication Systems. Lincoln automatic centralized systems are sealed from pump to bearing, delivering refinery-fresh lubricant at all points simultaneously, while machinery is operating.

Systems are available for manual, semi-automatic or fully automatic application. Mail the coupon now for complete details.

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Please send my copy of Catalog 82, illustrating and describing Lincoln Power Lubrication Systems for heavy-duty equipment.

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Company..

Address..

City.................. Zone....... State.........................

nlgi spokesman

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THE COVER

REMINDERS like this may be found on the bottom of quart cans of motor oil in the future, as a way to remind the driveway salesman of another customer service . . . of another profitable sale. The plan, as envisioned by the NLGI Chassis Lubrication committee would be for occasional cans to be embossed with the prompter message, tying in for complete lubrication service. The committee has distributed this idea through their Chassis Lubrication Bulletin Number Three . . . part of a series going to leaders in the industry, promoting lube jobs and consumer acceptance of this need for automobile maintenance.

NLGI PRESIDENT'S PAGE

By H. A. MAYOR, JR., *President*

An Open Letter

Mr. Ralph R. Matthews
Independent Oil Compounders Association
4638 Nichols Parkway
Kansas City 12, Missouri

Dear Ralph:

What a shock it has been to your many grease industry friends to hear of your continuing health problems. Then to have these further complicated by the serious illness of your wife makes us even more concerned for you. It goes without saying, that if there is anything any of us can do for you during these trying times you have but to call upon us.

From the personal to the business vein, you will be happy to know that a majority of the NLGI Board Members have voted to temporarily authorize our General Manager, T. W. H. Miller's professional assistance for you during your period of recuperation and recovery. The NLGI is doing this to guarantee that adequate efforts will be made to insure another successful IOCA Annual Meeting in September at Hotel Moraine-on-the-Lake in Highland Park, Illinois. We know you well enough to realize how concerned you are with the current welfare of the IOCA and how anxious you are that the members be properly served. This is but a small NLGI effort to repay you for the many good things you have always done for the NLGI—and for those within the grease fraternity.

May God bless you and best wishes for a complete and speedy recovery.

Yours very truly,
H. A. MAYOR, JR.
President

News About NLGI

Chassis Lubrication Needs Material to Continue NLGI Committee Work

NLGI's Chassis Lubrication Committee, chairmanned by J. W. Lane, has just released their Bulletin Number Three to all Institute members and selected lubrication management, throughout the country.

Each bulletin is composed of booklets, reprints, ads and promotions for automobile chassis lubrication, and their purpose is to disseminate ideas throughout the industry which can be modified and employed by firms marketing lubricants (The prompter message on the cover is an example of the committee at work).

Participation is not restricted to members and all readers of the journal are invited to forward examples of successful lubrication material to the committee. In order to make the program a success, a broad base of participation is necessary. Material may be sent to either the national office or to Mr. W. J. Lane, Socony Mobil Oil Co., 150 East 52nd St., New York 17, N. Y.

Helping Out IOCA

As noted on the President's Page (162), the General Manager of NLGI has been authorized by the Board of Directors to assist the Executive Secretary of the Independent Oil Compounders Association in the preparation of their annual meeting.

IOCA's managing executive, Ralph R. Mathews, has not been in good health and will be assisted by the Institute's T. W. H. Miller, through completion of the 13th IOCA annual meeting . . . at the Hotel Moraine, Highland Park, Illinois, September 25, 26, 27.

Matthews and Miller have always cooperated closely in the past. The national offices of both organizations are just a few doors away in the same building and joint membership by many firms, plus the parallel activities, have made for an exchange of assistance between the two, over the years.

Annual Fall Board Meet

There will be a meeting of the NLGI Board of Directors in September, the regular fall session in New York City on Monday, the 12th. The governing body will meet at the Roosevelt hotel.

Offer New NLGI Glossary for Sale

The NLGI Glossary, a gathering of terms and definitions relating to the lubricating grease industry, has been distributed to the entire membership.

First published in three successive issues of the NLGI SPOKESMAN, the terms were then alphabetized and offered in the last issue (July, 1960) as a complete set. Printing and distribution of a four-page booklet then followed.

Members may purchase the glossary beyond their complimentary copies at fifteen cents each. The charge for non-members is twenty-five cents.

Technical Committee Column

CHAIRMAN L. C. BRUNSTRUM
Research & Development Dept.
Standard Oil Company (Ind.)
P. O. Box 431
Whiting, Ind.

I. Mathematical Symbols for NLGI Articles

Our paper procurement committee had just started work on a suggested list of mathematical symbols for NLGI articles when it was learned that ASLE had proposed their list to ASA. The advantage of adopting the ASLE list is obvious, if it meets our needs. Because lubrication enters so many fields, it is unlikely that the ASLE list will meet every need, but we believe it should be made universal enough to satisfy NLGI requirements including rheology.

With this in mind your chairman attended the June 30 meeting of committee Z-11. It was pointed out that NLGI could not fully accept the present list in view of certain duplications (R for both radius and shear rate, for example) and that some other symbols were already used in D-2 ASTM methods.

The ASLE list would undoubt-

News About NLGI—cont'd

edly satisfy NLGI needs if minor revisions were made. Some of these are the addition of η for the apparent viscosity, use of F and S for shear stress and shear rate rather than the present S and R, and in general eliminating duplications.

ASA agreed to withold approval at this time and the ASLE representative agreed to consider minor revisions. This will provide NLGI and other organizations a better opportunity to consider the ASLE list. Because this list will be reconsidered by ASA, it would be desirable for the membership of the NLGI Technical Committee to offer their opinions at an early date. Please make your comments to C. J. Boner, L. C. Brunstrum, or M. L. Carter.

The proposed ASLE list is shown.

A.S.L.E. Standard Mathematical Symbols for Lubrication Problems

General Principles. 1. The principles of standardization established by the American Standards Association have been carefully followed and the choice of individual symbols already established for related branches of engineering.

2. Separate symbols are not given for all the quantities which are encountered in lubrication calculations but only for those quantities which are in common use and which would involve confusion if different authors used different symbols.

3. Alternate symbols are permitted where possible, provided they do not result in confusion with symbols for other quantities.

4. The establishment of a given symbol to represent a given quantity does not mean that an author cannot use the same symbol to represent another quantity for which no symbol has been assigned. It merely means that when dealing with quantities for which standard symbols exist, he should use the standard symbol.

5. The establishment of a symbol for a quantity does not determine the units in which the quantity is to be expressed. Any consistent system of units is satisfactory.

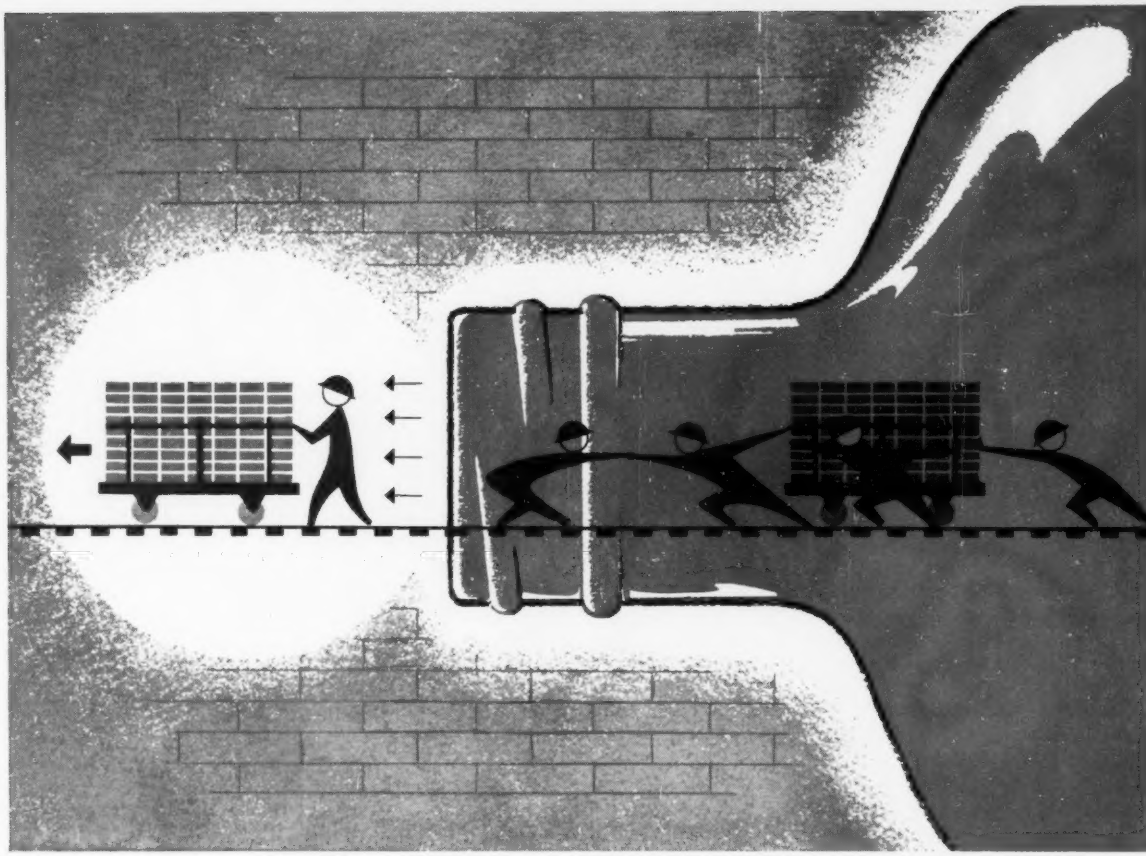
6. To avoid confusion with letter symbols employed in the text, Roman letter symbols, subscripts, and Roman letter superscripts used for mathematical quantities should be in italics. Italics should not be used for Arabic numerals, Greek letters, and modifying signs and operators. On a manuscript, each letter to be italicized should be individually underlined.

MATHEMATICAL SYMBOLS FOR LUBRICATION PROBLEMS

a	acceleration, angular
g	acceleration, gravitational
a	acceleration, linear
$\alpha, \beta\ \gamma \ldots$	angles
w	angular velocity
A	area
B, b	breadth, width (par. to dir. of motion)
C, c	clearance, radial
f	coefficient of friction
α	coefficient of linear expansion
p	density, mass per unit vol.
D, d-	diameter
e	eccentricity, brg.-jnl. center dist.
ϵ	eccentricity ratio, eccen./-rad. clear.
η	efficiency
δ	elongation, deformation, displacement
E	energy
h	film thickness, thickness
W	force, load
F	friction force
q	heat rate, heat flow rate, heat per unit time
λ	heat transfer coefficient, heat flow rate per unit area per degree
L, l	length (perp. to dir. of motion)
W	load
P	load per unit proj. area
G	lubrication number, μN/P, ZN/P
m	mass
J	mechanical equivalent of heat
M	moment of force
n	number
H	power
p	pressure, force per unit area
R, r	radius
N, n	revolutions per unit time
r, s	shear stress
R	shear rate
S	Sommerfeld number$(R/C)^{-2}$ $(\mu N/P)$
c	specific heat
T	temperature, absolute
t, s	temperature, ordinary
Δt	temperature difference, temp. rise
k	thermal conductivity, heat flow rate per unit area per unit length per degree
t	time
M	torque
u, v, U, V	velocity
μ, Z	viscosity, absolute
ν	viscosity, kinematic
V, V_1	volume
Q	volume rate, flow rate, vol. per unit time
γ	weight per unit vol.
W_k	work

II. The 1961 ASTM-NLGI Symposium

The ASTM-NLGI symposium on the significance of oil viscosity in lubricating grease will undoubtedly be conducted as a concurrent technical meeting on Tuesday afternoon, October 31, 1961. Details are being handled by R. S. Barnett for ASTM and J. J. Dickason of our Manufacturing Subcommittee. They have pointed out that offers of papers are now being accepted. Offers may be made to either society. They are particularly anxious to hear from users of grease and will welcome papers tending to show why oil viscosity ranges are required in grease purchasing specifications.



New "hot" grease ends brick-oven bottlenecks

...and one man outperforms four!

Ceramic Combustion & Engineering Company, consultants for the Davidson Brick Co., Los Angeles, California, ran into production bottlenecks while using ordinary grease in dryer-car bearings. Oven temperatures (350° to 400° F.) cooked the grease solid . . . stalled the cars loaded with bricks in the dryer. Bearings seized so badly that four men were needed to move each carload.

Now—with Shell Darina Grease 2 as the lubricant, Davidson reports: "Bearings roll free, even at 400° F., one man, instead of the four previously required, can *easily* roll a carload of bricks . . . no more bottlenecks caused by frozen bearings."

Darina® Grease 2 is an economical, multi-purpose grease with exceptional stability in high-temperature applications. It offers these outstanding qualities:

HIGH-TEMPERATURE PERFORMANCE. *100° F. better* than conventional multi-purpose greases.

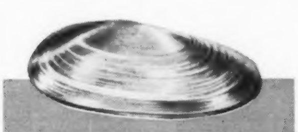
EFFICIENT SEALING. Contains no soap —nothing to melt and run out.

HIGH RESISTANCE TO WATER WASH-OUT. Doesn't dissolve or separate when mixed with water . . . lubricates efficiently under wet conditions.

POSITIVE RUST PROTECTION. Protects bearings even under severe moisture conditions.

ECONOMICAL. Savings up to 35% in grease and labor costs alone are possible because of Darina's superior performance over a wide range of plant operating conditions.

For more information on Darina Grease, write: Shell Oil Company, 50 West 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.



An Interesting Fact! Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here: Darina solenoides.

SHELL DARINA GREASE

the multi-purpose, high-temperature grease

SHELL

Future Meetings

SEPTEMBER, 1960

11-16 American Chemical Society, 138th National Meeting, headquarters undecided, New York.

14 API Division of Marketing, lubrication committee meeting, Hotel Traymore, Atlantic City, New Jersey.

14-16 National Petroleum Association Annual Meeting, Hotel Traymore, Atlantic City, New Jersey.

18-20 IOCA 13th Annual Meeting, Hotel Moraine, Highland Park, Ill.

18-21 ASME Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.

OCTOBER, 1960

9-13 ASTM, Committee D-2 meeting, Mayflower Hotel, Washington, D. C.

10-12 API Division of Marketing, marketing research committee, Baker Hotel, Dallas.

17-19 ASME — ASLE Lubrication Conference, Statler Hilton Hotel, Boston.

OCT. 30 - NOV. 2 NLGI Annual Meeting, Edgewater Beach Hotel, Chicago

NOVEMBER, 1960

2 Packaging Institute, petroleum packaging committee meeting, headquarters undecided, New York.

3-4 SAE National Fuels and Lubricants Meeting, Mayo Hotel, Tulsa, Okla.

14-16 API 40th Annual Meeting, Conrad Hilton, Palmer House and Congress Hotels, Chicago.

15-17 Air Force—Navy—Industry Propulsion Systems Lubricants Conference (unclassified), Hilton Hotel, San Antonio, Tex.

27-Dec. 2 ASME Annual Meeting, Statler Hilton Hotel, New York.

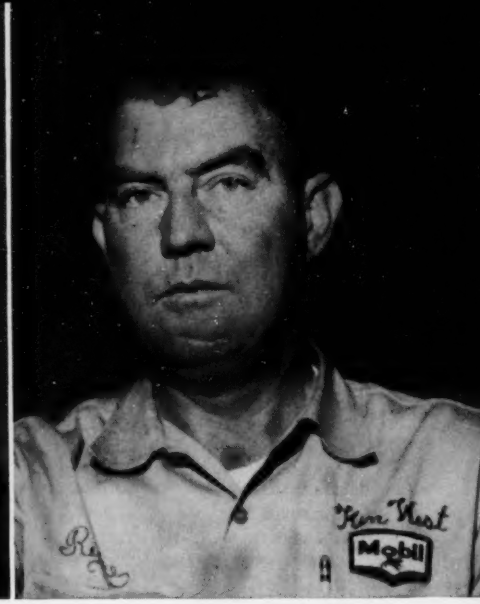
JANUARY, 1961

9-13 Society of Automotive Engineers Annual Meeting, Cobo Hall and Convention Arena, Detroit.

OCT. 29 - NOV. 1, 1961 NLGI Annual Meeting, Rice Hotel, Houston, Tex.

"Since standardizing on Trojan HM 'Moly' Grease, my gasoline sales *alone* have gone up 35%. TBA and oil sales are up and I've gotten new customers from way out of town." Joe Scillieri, Joe's Cities Service Station, Hackensack, N.J.

"Once a customer tries Esso MP Grease ('Moly') he can feel the difference immediately. And each time he comes back, we get a chance to sell more gas, oil and TBA than we ever did before." Jim Elborn, Elborn's Imperial Esso Service Station, Don Mills, Ontario.



"Word about my Mobilgrease Special (with 'Moly') lube jobs spread fast. I began to pick up a lot of new local business, repeat business. Sold a lot more gasoline, oil and TBA." Richie Christenson, Ken West Mobil Service Station, White Plains, N.Y.

How "MOLY" multi-purpose greases boost service station traffic

A good, profitable service station business is built on confidence in the operator. And, nothing builds confidence as fast as benefits customers can notice right away.

Easier steering, no squeaks, quieter riding — customers can feel these benefits within a few blocks when they get a "Moly" multi-purpose grease job for ball joints, wheel bearings and other grease lubricated parts.

The reason: "Moly" Greases contain Molysulfide®, an additive that puts extra lubricity into a grease, gets in between rubbing metal surfaces fast . . . and stays there! Won't squeeze out or wash out.

Result: Customers not only come back for repeat jobs, they become service stations' best salesmen. New customers come in. From then on, it's up to each dealer to take advantage of the increased traffic.

Get the facts on what "Moly" Greases can do for service station sales. For details, write Climax Molybdenum Co., Div. of American Metal Climax, Inc., 1270 Avenue of the Americas, New York 20, N. Y.

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Amoco • Cities Service • Conoco • Crown • Frontier • Gulf • Jenney • Mobil • Pennzoil • Phillips • Sinclair • Skelly • Std. of Ind. • Std. of Ky • Sunoco • Texaco CANADA: B-A • Canadian Oil Cos. • Cities Service • Esso Imperial • Sunoco • Texaco

NLGI Associate, Technical

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ANNUAL MEETING, 1960

Tentative Titles, NLGI 28th Annual Meeting
Edgewater Beach Hotel, Chicago, October 30—November 2

NLGI Annual Meetings continue to get larger and the 28th is no exception . . . there will be more papers presented than ever before and each has been initiated because of member interest and requests. A full day of concurrent sessions on Tuesday, November 1, will offer an unusual program devoted to industry facets from both the marketing and technical standpoints. The general session on Monday, October 31, will be of interest to the entire membership. Titles listed below are tentative and will be confirmed in later issues of the journal. The line-up is as follows:

Sunday, October 30
- "Mr. and Mrs. Early Bird Reception" sponsored by 26 Associate member firms

Monday, October 31 (*General Session A*)
- Address of Welcome
- Keynote Speaker
- Selling the Lubricating Grease Market
- DUTCH TREAT LUNCHEON

Monday, October 31 (*General Session B*)
- NLGI ANNUAL BUSINESS MEETING
- Why Wire Rope Lubricants Are Special Compounds
- New Grease Plant Layout
- What's Ahead in Farm Machinery Lubrication
- A Review of NLGI Fellowship Activity

Tuesday Morning, November 1 (*Marketing Session A*)
- New Developments in High Temperature Grease
- Aero/Space Grease Requirement Trends
- Lubrication of Nuclear Power Plants
- Future Package Trends and Designs for Lubricating Greases

Tuesday Afternoon, November 1 (*Marketing Session B*)
- Lubricating Grease Requirements of 1961 Cars
- Centralized Lubricating Systems
- A Rapid Method for Predicting the Flow Properties of Greases
- Lessons to Be Learned from the Cato Grease Plant Fire
- Novel Quality Control Tests for Use in Grease Plants
- 1958 Federal Food Additives Amendment

Tuesday Morning, November 1 (*Technical Session A*)
- The Permeability of Lubricating Grease
- Structural Changes and Phase Transitions in Lithium Grease
- Electron Microscope Examination of Thin Film Sections of Lubricating Greases
- A Rheological Equation for Greases

Tuesday Afternoon, November 1 (*Technical Session B*)
- Oxidation of Lubricating Greases
- NLGI Fellowship Report
- Report on Fellowship Activities
- Question and Answer Period
- ANNUAL SOCIAL HOUR
- ANNUAL BANQUET

Wednesday Morning, November 2
- Subcommittee Meetings
- NLGI TECHNICAL COMMITTEE MEETING
- Reports of Subcommittees

F. R. Hart (Standard of California) is chairman of the program committee, assisted by S. C. M. Ambler (British American), C. L. Johnson (Jesco), W. A. Magie, II (Magie Brothers) and T. F. Shaffer (Shell).

Presented at the NLGI 27th annual meeting in New Orleans, October, 1959

REVIEW OF RESEARCH STUDIES SHOWING NEED FOR A VISCOSITY TEST BELOW 1 SEC.$^{-1}$

By: E. L. Armstrong
Socony Mobil Oil Co., Inc.

A GREAT DEAL of research work has been done in many laboratories in the past few years in studying the problem of the flow properties of lubricating greases. The associated studies of grease structure are also of direct importance since research in either area is a stimulus to the other.

For example, at the annual meeting of this Institute, we have heard papers and symposia dealing with flow properties, structure or dispensing problems in six out of the last seven meetings. This is certainly a good indication of the relative effort being devoted to these problems. Likewise, in the past few years other technical societies such as ASLE, ASME, ACS and AISE have also presented the results of work in this field.

For the most part, the research studies reviewed in this paper are those reported in the publications of this Institute. If we go back some 40 years to the year 1919, we find Messrs. Bingham and Green[1], working in the research laboratories of the New Jersey Zinc Co., demonstrate that paint is not a viscous liquid but is a plastic material. They showed, by using a capillary type of viscometer, a pressure tank and a pressure regulator, that two paints with identically the same mobility as measured in a Stormer viscosimeter (a torsion type of instrument) had a difference in yield value. In other words two paints looked the same but one will flow from a spatula in a continuous stream, while the other is just able to drop off. The latter has a much higher yield value.

Two years later in 1921, Mr. Buckingham[2] reported his mathematical analysis of Green's and Bingham's observations on plastic flow and showed that the type of flow exhibited by the paint must be a "plug flow" phenomenon since a part of the velocity profile is undergoing no shearing effect.

It wasn't until 1954, 35 years later, that Messrs. Mahncke of Westinghouse and Tabor of Harvard[3] demonstrated and photographed *the plug flow profile of a lubricating grease* in contrast to the parabolic profile of a lubricating oil and gave further support to the Bingham Body model for lubricating greases.

Going back now to 1931 and 1934, Mr. M. H. Arveson[4] of the Standard Oil Co. of Indiana reported the results of his study of the flow of petroleum lubricating greases with a capillary type of viscometer covering a range of shear from 0.08 up to 132,000 seconds^{-1}. His viscometer employed a piston, driven by means of a variable gear drive, forcing the test material through a capillary at a constant rate. He found that the apparent viscosity of greases under increasing shear rate was characteristic of the particular soap used and that the limiting viscosity of the grease at very high rates of shear approached the viscosity value of the oil used in making the grease. A general curve correlation was worked out on the basis of the viscosity of the oil in the grease at the particular temperature, a soap content factor and the rate of shear.

In 1942 Messrs. Beerbower, Sproule, Patberg and Zimmer[5] of the Esso Laboratories reported to NLGI on the design of a simplified constant flow rate pressure viscosimeter employing a constant volume Zenith gear pump to hydraulically displace the grease through a suitable capillary. This "S.O.D. Viscometer" design was subsequently standardized by ASTM and published as a tentative method of test for apparent viscosity of lubricating greases in 1950. This test, ASTM

D-1092-55, is limited to a minimum shear rate of 10 reciprocal seconds.

In 1946, Messrs. Roehner and Robinson[6], Socony Mobil Laboratories, reported on the apparent viscosity effects of variation of concentration of four typical soaps in different mineral oils, using the SOD Viscometer apparatus. Their results showed that such factors as soap type, concentration, mineral oil viscosity, test temperature and rate of shear all affected the apparent viscosity of the product.

In the 1953 NLGI symposium on "Dispensing Lubricating Greases in Service Stations and Garages," Messrs. Stokely and MacDonald[7] of the California Research corporation discussed "Grease Characteristics That Significantly Affect Dispensers." They showed how mineral oil viscosity, consistency, additives and grease temperature were most significant in affecting grease flow from the dispensing pump. Also, they demonstrated that two factors are of major influence on flow to the dispensing pump, namely, the unworked consistency of the grease and the thixotropic behavior of the grease. Extreme thixotropy, where a grease gradually hardens with time, must be avoided, as well as a freshly made grease which is too stiff to flow, causing the grease pump to cavitate (air enters along the pump suction line in the center of the container).

In this same symposium, Mr. N. Marusov[8], Gulf Research & Development Co., in discussing the work of the Dispensing Panel stated, "The exploratory work included full scale tests with five different makes of pumps and three different types of lubricating greases. Good correlation was obtained when minimum pump deliveries were compared with ASTM viscometer results measured at 200 sec.$^{-1}$. This shear rate approximates the shear rate in the restrictor at a delivery of two ounces per minute."

At the 1954 NLGI meeting, Messrs. Dreher, Carter and Reid[9] of California Research corporation reported some data developed with the aid of a statistical method showing quantitatively the dependency of apparent viscosity on soap content, viscosity of the mineral oil and worked penetration of the grease. This type of quantitative relationship capable of predicting apparent viscosity with reliable accuracy is a valuable aid in the manufacture of greases for the military which must comply with specified apparent viscosity requirements. A nomograph for calculation of apparent viscosity was developed by the authors for this purpose.

At this same meeting, Dr. B. W. Hotten[10] and Dr. I. E. Puddington[11] discussed the possible relationships of grease structure of still and flowing greases. Dr. Hotten gave a pictorial representation of separation, orientation, and/or rupture of the fiber network which may take place during the flow process. Dr. Puddington discussed the properties of a desirable type of grease structure which would have the ability to undergo reversible changes in apparent viscosity as the rate of shear is altered.

Dr. R. H. Leet[12] reported on the effects of thickener particle dimensions and interparticle attractions on grease consistency changes that occurred upon working and subsequent aging.

Dr. Marjorie J. Vold[13] discussed the "Forces Responsible for Lubricating Grease Structure." She described the attractive forces operative between colloidal particles which account for the yield value and consistency of greases. She also speculated on the existence of repulsive forces strong enough to exceed the attractive forces to account for phenomena such as shear breakdown, age and work hardening and thixotropy.

In 1955, NLGI held a symposium on the "Flow Properties of Lubricating Greases." In these discussions, Dr. Henry Eyring[14] of the University of Utah gave a critical review of the basic principles of flow of non-Newtonian fluids from a molecular viewpoint. His equation may ultimately permit a correlation of flow behavior with properties of the thickener particles.

Messrs. Forster and Kolfenbach[15] of Esso Research and Engineering Co., by means of X-ray diffraction and electron microscope studies, showed that the formation of a three dimensional network of soap fibers is attributed to the ability of the soap fibers to stick to each other at points of mutual contact. They calculated the forces holding the network together and qualitatively related this information to the effect of shearing on the grease structure.

Messrs. Brunstrum and Leet[16] of the Standard Oil Co. (Ind.) discussed the problems of interpretation of flow rate and pressure data obtained in measurements of grease flow in capillary viscometers. They outlined four differing mathematical treatments, with the choice depending on the type of problem under study.

Miss Ruth Weltmann[17] of the NACA Lewis Flight Propulsion Laboratory reported on a study of two automotive chassis greases in a concentric-cylinder rotational viscometer. She showed that one grease behaved as a pseudoplastic material while the other showed a thixotropic flow behavior. The non-Newtonian flow properties of these greases were used to demonstrate the calculation of pressure losses for different pipe line systems and flow conditions. The calculated pressure losses illustrated that the flow behavior of a lubricating grease in a pipe line is quite different from that of a lubricating oil.

A third section of the 1955 symposium was concerned with the practical application of rheological data. Mr. L. C. Rotter[18] of Lincoln Engineering company outlined the need for a common language de-

scribing grease viscosity and flow properties to enable the pump manufacturer to design and select the proper equipment for any length or size of supply line.

Messrs. Koenig, Johnson and Baniak[19] of Texaco's Beacon Laboratories described their work on various greases to determine a correlation between pressure drop in the distribution system elements and the apparent viscosity of the grease used.

Mr. J. S. Aarons[20] of U. S. Steel's National Tube division described a laboratory pumpability test on various greases at low temperatures and a correlation of the laboratory results with field practices.

In the question and answer period at the end of the 1955 symposium, one prophetic question was asked Miss Weltmann by Mr. Brunstrum. He inquired, "Will the grease industry eventually be forced to replace the long-established pressure viscometer?" She answered that she believed the grease industry will eventually prefer to use rotational viscometers for certain flow measurements. This in order to obtain direct flow curve measurements (rate of shear versus shearing stress) which for most materials are representative of the flow character of the tested material. This compared to a capillary tube viscometer where the rate of shear changes from zero in the center to a finite value at the wall necessitating rather complicated corrections for an interpretation of the flow behavior of non-Newtonian materials. Also, when dealing with time-dependent or thixotropic greases, rotational viscometers have another advantage. The test sample remains in the test chamber and thus can be given a treatment simulating industrial conditions by applying a constant rate of shear over a given period of time, or by changing the rate of shear in accordance with a desired program.

At the 1957 NLGI meeting, Dr. D. W. Criddle[21] of California Research corporation explained the usefulness of his new equation to correlate and predict grease flow based on three factors: a) the flow rate expected for the oil; b) a term which correlates for the volume fraction thickener; and c), a term determined by the yield stress and the shear breakdown. The (c) term is a function of relative pressure which is novel in correlating flow data. Criddle's equation is shown to fit at the low shear stress region when a wide range of shear rates is to be fitted. (It would be extremely useful to have a standardized viscosity test below 1 sec.$^{-1}$ shear rate for reference along with Criddle's new equation).

In the May, 1958 issue of *Lubrication Engineering*, Messrs. Miller, Walsh and Slaymaker[22] of Case Institute of Technology reported on a study of the "Effect of Capillary Length-to-Diameter Ratio on Grease Viscosity" on seven greases. They made tests at 75°F and 40°F. A change in apparent viscosity occurred in all seven greases for capillary length to diameter ratios up to 250:1. Beyond this point there was generally little change in apparent viscosity up to the 1000:1 ratio studied. They made their studies over a shear rate range of 2 to 500 sec.$^{-1}$ which they believed approximated those in centralized systems.

At last year's Symposium on Flow Properties and Rheology Studies, Messrs. Sisko, Brunstrum and Leet[23] showed that the flow of lubricating grease over the wide shear rate range of 10^{-1} to 10^{1} reciprocal seconds can be simply and accurately described by the equation:

$$F = a\dot{s} + b\dot{s}^n$$

where F is the shearing stress; $\dot{s}$ is the rate of shear; and a, b and n are constants for each grease. In the conclusion of this paper, they state as follows:

> "In addition to being useful for engineering purposes, the constants a, b and n characterize the flow behavior of a grease and would be useful in drafting specifications and correlating grease properties. *To determine these constants accurately, the shear-rate ranges of standard grease viscometers should be extended down to at least* 1 *sec.*$^{-1}$."

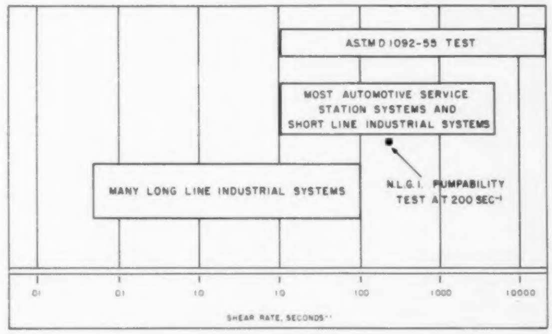

FIGURE 1—Comparative shear rates.

In Figure 1 of their paper data are shown from a pipe viscometer (consisting of a twenty-two foot length of 1.5 inch pipe) for a shear rate range from about 0.02 sec.$^{-1}$ up to about 11 sec.$^{-1}$.

At the April, 1959 annual ASLE meeting Messrs. Simon and Armstrong[24] reported on an investigation of grease flow in a long-line system in a steel mill. The shear rates in the centralized system in the plant varied from as low as 0.05 sec.$^{-1}$ in 2-inch piping up to about 100 sec.$^{-1}$ in ⅜-inch tubing. Flow rates below, at and above normal were investigated. Figure 1 shows the comparative shear rates as reported in this paper. You will note that most automotive service-station systems and short-line industrial systems cover a shear rate range from about 10 sec.$^{-1}$ to about 5,000 sec.$^{-1}$. On the other hand, many long-line industrial systems cover a shear rate from about 0.05 sec.$^{-1}$ to about 100 sec.$^{-1}$ The present ASTM D-1092-55 capillary viscometry test covers a shear rate range from about 10 sec.$^{-1}$ to more than 10,000 sec.$^{-1}$. You will also note on Figure 1 that the NLGI Pumpability Test has been standardized

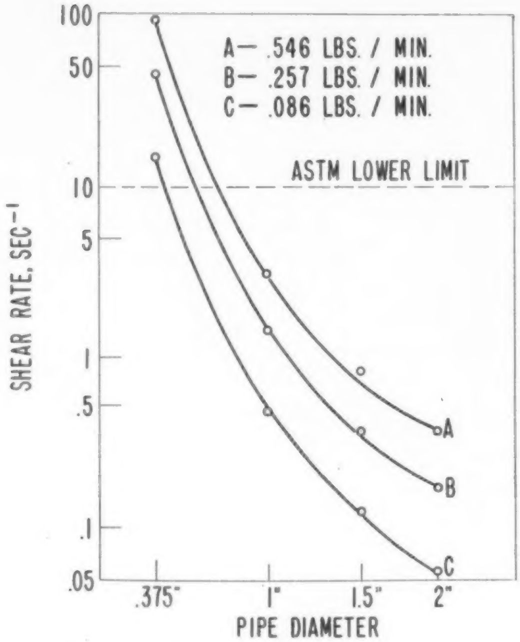

FIGURE 2—Shear rates in the various pipe sizes.

at a shear rate of 200 sec.$^{-1}$ for automotive service station greases. The data in this paper demonstrate that test criteria at very low shear rates, down to approximately 0.1 sec.$^{-1}$ are needed to evaluate greases for long-line industrial systems.

It is plainly evident that we must now measure grease viscosity below the range of the present ASTM method. It is the opinion of the Fundamental Research Committee that the development of a suitable method for subsequent standardization is an NLGI job which should get started immediately.

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About the Author

E. L. Armstrong *received a BS degree in chemical engineering from Purdue university in* 1940 *and a MChE degree from Brooklyn Polytechnic Institute in* 1948. *He has been associated with Socony Mobil Oil Co. in the Brooklyn laboratories for* 19 *years. He is supervisor of the applied research and development section—Brooklyn laboratory of Socony's research department. Author of several U. S. patents dealing with lubricant compositions and processing, he is a member of AIChE, ASLE, ACS, Sigma Xi and the New York Academy of Sciences; is active in ASTM and CRC; and has been a member of fuels and lubricants panel-working groups, Department of Defense. Chairman of the NLGI Fundamental Research subcommittee, he is a frequent contributor.*

Dispensing Symposium—VI

(Conclusion)

DISCUSSION

A Critique of Papers Presented in the 1959 Annual Meeting Session Entitled: "Spotlighting Our Dispensing Problems"

By: L. C. Brunstrum

Standard Oil Company (Indiana)

THE FIVE PAPERS on the dispensing of automotive greases in service stations presented at the annual meeting, climax ten years of work by the Dispensing Panel. That session was a tribute to the determination of that panel which, according to T. G. Roehner's estimate, may have spent as much as $100,000 developing the NLGI dispensing method and advancing our knowledge of how grease flows. The papers by Messrs. Skoglund and Gabbert are likely to provoke such additional questions as:

If dispensing involves shear rates of 1 to 5,000 reciprocal seconds under conditions that prohibit exact calculations of flow, how and why does the correlation using 200 reciprocal seconds "work"?

What is the relation of Mr. Gabbert's viscosity-dispensing curve (now a part of the method) to the earlier solutions of the committee?

What are the limitations of the NLGI method?

The last three by Messrs. Garretson, Bailey and Armstrong lead to the question:

Can the present method which deals with automotive equipment be extended to industrial systems?

Some considerations have already been given to such questions.

Correlation at 200 Reciprocal Seconds

Last year Dr. Sisko described a flow equation according to which grease viscosity is the sum of the one Newtonian and one non-Newtonian flow unit. The numerical proportions contributed by each is readily calculated from pressure viscosity data obtained by ASTM method D-1092. For two samples nearly identical to two used by the committee, the contributions and total viscosity in poises at 77°F. at three selected shear rates were:

Sec.$^{-1}$	1	200	5000
Newtonian, a	5	5	5
Non-Newtonian, bS^n	2520	40	3.2
Total apparent viscosity	2525	45	8.2
Newtonian, a	22	22	22
Non-Newtonian, bS^n	2340	32	3.2
Total apparent viscosity	2362	54	25.2

The dispensing rates will be proportional to some practically incalculable average of viscosities at several shear rates.

Because we desire to use a single readily obtained number to correlate with flow, the question is: Which of the grease properties in the table fits best? The problem would be greatly simplified had it been the Newtonian unit because it does not vary with shear rate. Unfortunately, the ratio of 5 to 22 is not the correct answer—another way of saying we cannot rely on a comparison of oil viscosities. Nor can we depend upon the soap contents or the penetrations, which are approximated by the ratios of the non-Newtonian units at low shear rate. The total apparent viscosities at either low or high shear rate vary widely and their ratios (2525 to 2362 or 8.2 to 25.2) do not correlate with the dispensing rates. On the other hand, the apparent viscosities at 200 reciprocal seconds (45 to 54) occur near the break in the viscosity-shear rate curve and reflect the contributions of soap and oil viscosity in about the right proportion. In some other system, dominated by flow at either very high or very low shear rate, viscosity at some shear rate other than 200 would be more suitable.

Comparison of Viscosity-Delivery Curves

Mr. Gabbert describes his curves as a dream; actually they have a good foundation in the work of the committee and carry it a step farther, as shown in Figure 1. The three viscosity-delivery curves represent, from left to right, an early plot published by the dispensing panel, a later plot, and Mr. Gabbert's curves rotated 90 degrees and viewed from the back. All three were copied as published; the variation in scales can be judged by the dotted areas of the center curve.

In the early committee work, a separate semi-log viscosity-delivery curve was drawn for each pump-grease combination. In later log-log plots, two greases were shown by separate lines although one line may have served the purpose. Mr. Gabbert has shown that, for a given pump and pressure, four chassis greases fall on a single line. In retrospect it would appear better to use a single curve on log-log paper. This raises the question of whether all chassis greases will fall on one line, or in other words, are there limitations to the method?

Limitations of the NLGI Method

Because we desire to estimate the delivery rate of any grease after testing only one, the committee attempted to answer the question. The answer is "No" if we are dealing with other chassis greases and "Yes" if we try to extrapolate to an oil on one hand or a heavy cup grease on the other. (Obviously we could determine how these materials dispense by using one of their type as the standard.)

The facts are that greases represented by the solid lines A, B, C, D, and E in Figure 2 have been successfully handled to date. All have apparent viscosities of between 50 and 200 poises at 200 reciprocal seconds and 77°F. Also all have nearly the same slope. A little more meaning to the slope is provided by the penetrations shown at the left and oil viscosities shown at the right.

The samples to be estimated need not fall in the range of 50 to 200 at 200 reciprocal seconds at 77°F. but they must have slopes similar to those represented by the A to E lines. A little consideration will show why this is the case. The sample to be estimated need not have the same apparent viscosity as the standard because the method allows for finding the temperature at which it

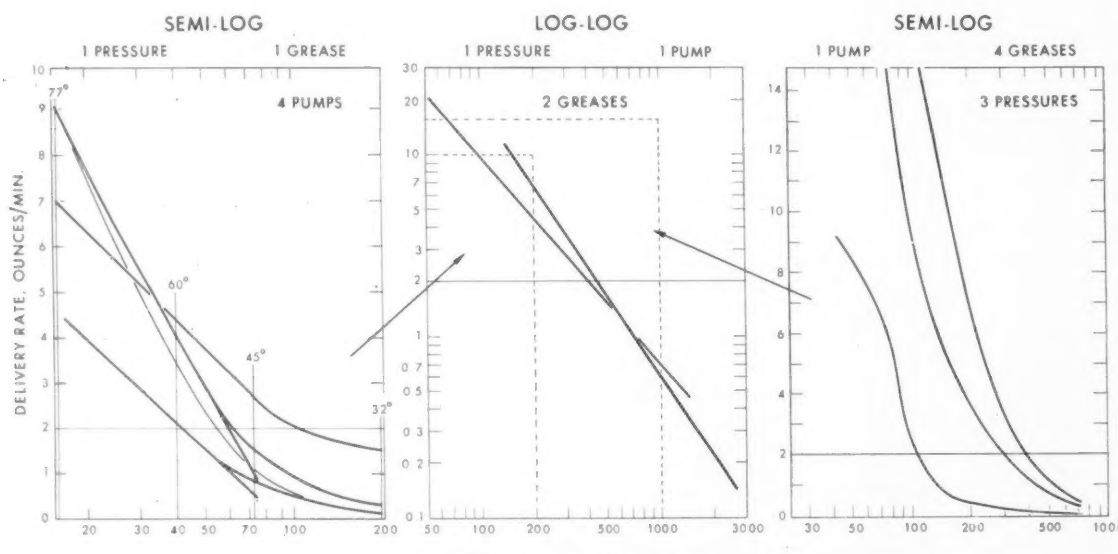

FIGURE 1—Comparison of method for plotting the data.

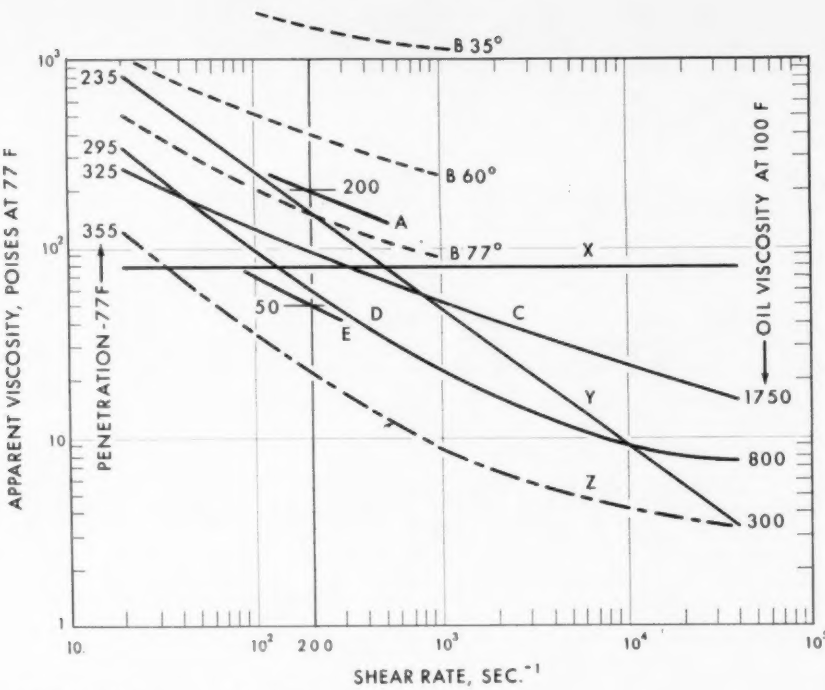

FIGURE 2—Limitation of NLGI Dispensing Method.

will. The standard or any other grease will change markedly with temperature as shown by the dotted line representing grease B at several temperatures. The dispensing rate should be predictable for even the soft grease represented by curve Z because at some temperature its apparent viscosity-shear rate curve should duplicate the standard within practical limits.

On the other hand, the η-S curve for the oil (horizontal line X) or the heavy cup grease (curve Y) can never approximate the curve for the chassis greases, even if they happen to be identical at 200 reciprocal seconds.

Future Work

General adoption of the NLGI dispensing method should save a great deal of testing expense, especially for pump companies. The delivery rate of any grease of a given type in any new chassis pump or dispensing layout can be estimated after testing one grease and comparing its apparent viscosity with that of any other. Most grease companies have agreed to furnish apparent viscosity data on their greases.

It now remains to be demonstrated whether or not the method applies to the more complicated central systems mentioned by Mr. Garretson or the relatively new layouts for bulk handling mentioned by Mr. Bailey. Because of the great variety of industrial greases and dispensing facilities, any method that offers a possibility of reducing testing time is attractive. The NLGI Dispensing Committee, composed of both pump and grease manufacturers, should be in a good position to consider the problem. As indicated by Mr. Armstrong, the Research Committee has already considered the possibility that a method for apparent viscosity at lower shear rates may be necessary. ■

About the Author

L. C. BRUNSTRUM *has been a member of the research department of the Standard Oil company (Indiana) since he received his BS degree in chemical engineering from Armour Institute of Technology in 1929. He is currently the section leader in charge of research on greases and industrial lubricants. A frequent contributor to the* NLGI SPOKESMAN, *he was appointed chairman of the Technical Committee at the* 1959 *annual meeting. In* 1958, *he was the seventh man to be honored by the "Award of Achievement," after five years as Technical Committee vice-chairman.*

New Thickener System Extends Range of Multipurpose Greases

By: J. J. Kolfenbach
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Presented at the Fifth World Petroleum Congress in New York, May-June, 1959.

Abstract

The trend toward multipurpose greases has been the outstanding development in the grease application field. This trend is desirable and is being encouraged both by manufacturers and users of greases. In order for the multipurpose approach to be considered in ever wider areas of application, it is necessary to have improved products. The popular lithium type multipurpose greases are limited in temperature-consistency characteristics and also in lubrication ability, particularly under heavy load conditions. While they are quite suitable for many automotive uses, their extension into certain general industrial and metal rolling applications is not practicable.

A new calcium complex salt thickener has been developed which thickens oil to form greases of greatly improved properties for multipurpose use. This thickener complex is formed *in situ* in oil from calcium acetate and calcium salts of high molecular weight fatty acids. The fatty acids mixture has a molecular weight of about 77. The calcium acetate exists entirely in the complex and no free calcium is present.

Greases prepared from this complex thickener have essentially flat temperature-consistency curves between 75-400°F. Even more important, they have excellent lubrication properties even under extremely heavily loaded conditions. The complex functions not only as a thickener but also as an extreme pressure agent, so that no reactive E.P. agents are required. The other desirable properties of a multipurpose grease such as resistance to water, structure retention after mechanical working, and oil retention properties are retained. Field experience has confirmed the laboratory indica-

tions that the calcium-complex grease is capable of lubricating a very wide range of equipment ranging from the relatively easily lubricated automotive vehicles to the difficult to lubricate metal rolling industry equipment.

Introduction

This report discusses the trend toward multipurpose greases, the development of a new thickener system for multipurpose greases of a broad range of uses and a comparison with conventional products.

Discussion

The growth of multipurpose greases in the United States has been the outstanding trend in the grease field. Approximately 25 per cent of the grease produced in the United States today is of the multipurpose type. The growth of the multipurpose market is perhaps best illustrated by reference to the production figures for lithium type greases, the most common type of multipurpose product. Lithium soap grease production increased from about 16 million pounds per year in 1946 to about 190 million pounds in 1957. Whereas most of the production had gone into military application previously, it now is going into a wide range of uses.

This trend has developed because it offers advantages both to the user and to the manufacturer. The advantages to the user are generally associated with the simplification resulting from dealing with a single product rather than with a multitude of products. Some of the major advantages are listed as follows:

1. Reduced frequency of lubrication errors.
2. Less equipment and time required.
3. Smaller inventory of grease required.
4. Less spoilage by contamination of opened packages.
5. Better lubrication.
6. Greater knowledge of properties of greases being used.

These advantages often outweigh the disadvantage of the higher price that generally is required for multipurpose products.

The grease manufacturer also appreciates this trend. The advantages to the producer are, in general, benefits derived from making large volumes of the single product rather than a great number of specialized products. The major advantages to the manufacturer are summarized as follows:

1. Better utilization of manufacturing equipment.
2. Smaller inventory of grease making ingredients.
3. Smaller inventory of finished greases.
4. Economics of bulk storage and bulk delivery.
5. Less bookkeeping.

These advantages both to the consumer and to the manufacturer suggest that the trend toward multipurpose greases is one which should be encouraged.

In order for this trend to continue and grow, however, it will be necessary to provide greases of a wider range of utility. The lithium soap greases as representative of the most common multipurpose type product today are limited in their high-temperature characteristics and also by their inability to lubricate well under conditions of extreme pressure. This is illustrated in the accompanying table, where the quality requirments for multipurpose greases in a number of fields of application are summarized along with the quality level provided by conventional lithium type products.

The quality levels indicated as being required for these different services are an average level. Within any one field of application, the quality requirements could differ markedly with different segments of the industry. For example in the automotive field, the anti-fretting quality requirement, listed in the table as "fair" can be very stringent in certain heavy duty truck wheel bearing assemblies. Also, some industries may minimize the lubrication life requirements by relubricating at more frequent intervals. Within such limitations of attempting to classify requirements for different fields, it will be noted that while the quality level of lithium type greases is sufficiently good that it can be used in automotive applications, there are many requirements in the general industrial field and metal rolling industry where the quality level of a lithium

Minimum Quality Requirements for Multipurpose Greases

		Fields of Application		
Properties	*Li Type Greases*	*Automotive*	*General Industry*	*Metal Rolling*
Retention of Consistency				
At High Temperature	Fair	Fair	Good	Good
At Low Temperature	Good	Good	Good	Good
On Extended Working	Excellent	Good	Good	Good
When Mixed with Water	Excellent	Excellent	Good	Excellent
After Oil Separation	Good	Good	Good	Excellent
Lubrication Ability				
Under Extreme Pressure	Fair	Fair	Good	Excellent
Anti-fretting	Fair	Fair	Fair	Good
Life in Motor Bearings	Good	Fair	Good	Good

type product would not be adequate. In particular, lithium type grease is inadequate in consistency retention at high temperature and in lubrication ability. Any major extension of the multipurpose grease approach into these industrial fields requires an improvement in high temperature-consistency stability and in lubrication characteristics, particularly under extreme pressure conditions.

The property of retaining consistency at elevated temperature is associated almost entirely with the thickener used in the grease. Greases made from conventional simple soaps generally soften markedly at temperatures in excess of 250°F. Non-soap greases such as are made with carbon black or silica as the thickener are quite good in this respect. However, such non-soap greases do not perform well under extreme pressure conditions and do not respond as well to E.P. additives as do soap thickened greases. The selected approach to developing a broad range multipurpose grease was to devise a thickener system of better temperature-consistency characteristics which could be made to operate under extreme pressure conditions. The composition of such a thickener system, and the properties of the greases produced through the use of this new thickener system, are described in the following section.

Presentation of Data

A new calcium-acetate complex thickener system has been developed for multipurpose greases which has excellent temperature-consistency characteristics. This thickener system also provides built-in extreme pressure and anti-fretting characteristics without use of reactive extreme pressure additives. These advantages are incorporated into greases without loss of desirable characteristics needed for multipurpose products. This new thickener system then has opened the possibility of significantly extending the range of applications for which a single multipurpose product can be used.

A. New Thickener System

The new thickener system is a complex formed from calcium acetate and calcium salts of higher molecular weight acids. The average molecular weight of the combined fatty acids is 77. The complex is made *in situ* in oil. Complex formation is demonstrated by X-ray diffraction studies which show the appearance of a new species different from any of the simple calcium salts.

Characteristic X-Ray Diffraction Lines of Simple and Complex Calcium Salts in Oil

	Characteristic X-ray Diffraction Lines (A°)					
Type of Ca Soap	12.4	11.5	9.5	9.0	8.3	7.9
Higher Molecular Wgt. Acids	+				+	
Acetate		+			+	
Complex			+	+		+

Large quantities of calcium acetate can be incorporated into this new complex. No free calcium acetate is observed in these complexes even at high ratios of calcium acetate to calcium salts of higher molecular weight acids.

The main advantage in using a complex thickener of lower average molecular weight is improvement in lubrication characteristics. Such complex greases have built-in extreme-pressure characteristics which are normally expected only in greases containing large amounts of special additives. The effect of the molecular weight of the thickener on extreme-pressure properties of 300-penetration greases is shown below:

Effect of Molecular Weight of Thickener on E. P. Properties of Complex Greases

	Average Molecular Weight of Acids Used		
E. P. Test	116	79	70
Timken Test, Lbs. Carried	20	45	55
Almen Test, Wts. Carried	15	15	15

Timken Test: Hardened steel ring is rotated at 800 RPM against steel test block while lubricant is fed to point of contact. Load is applied through calibrated lever arms. Appearance of wear scar denotes passage or failure in test.

Almen Test: Load applied through a hydraulic system to a split bushing and journal immersed in lubricant. Lubricant failure is measured by journal condition or journal shearing.

Calcium complex soap had earlier been recognized as being desirable thickeners for greases by Carmichael and Hain[1] and Amott and McLennon.[2] Generally, these complexes were made from acids having a much higher average molecular weight, for example, a 1/1 mol. ratio of acetic and C_{18} fatty acid with an average molecular weight of 172. Although greases made from such complexes have many desirable properties they do not have the extreme-pressure properties observed with greases made from lower molecular weight complexes.

Comparison of E.P. Properties of Previous Complex Greases with New Product

E. P. Test	*Previous Complex* 172 Mol. Wt. Acids	*New Complex* 77 Mol. Wt. Acids
Timken Test, Lbs. Carried	20	45
Almen Test, Wts. Carried	9	15

Complex greases made from acids of low average molecular weight provided the improved lubrication necessary to extend greatly the ranges of applications of a multipurpose grease.

B. Properties of Multipurpose Greases

The properties of the new complex greases are outstanding for multipurpose application. Their consistency-stability characteristics are greatly superior to the conventional lithium type multipurpose products and their lubrication characteristics far exceed the minimum quality levels required of multipurpose products.

CONSISTENCY CHARACTERISTICS

The new calcium complex thickener is outstanding in its ability to retain a fixed consistency as temperature is changed. It shows essentially the same penetration at 400°F. as it has at 100°F. A conventional lithium soap grease shows a marked change in consistency with temperature as shown in Figure 1. At approximately 280-300°F. a conventional NLGI Grade 2 multipurpose grease is so soft that it could no longer be retained except within equipment utilizing efficient seals. In contrast, the NLGI Grade 1 improved multipurpose grease is sufficiently hard at this temperature to be easily retained without seals.

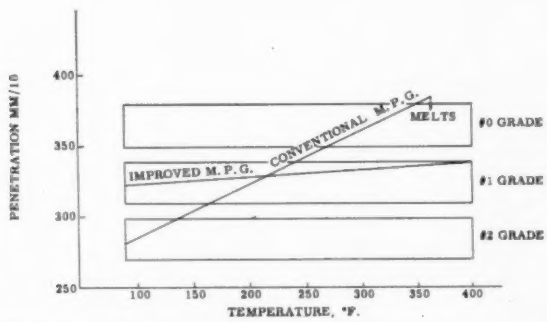

FIGURE 1—Consistency stability with increasing temperature.

The flat consistency temperature curve for the calcium complex grease suggests that a single grade of this product could be expected to be useful over a temperature range which might normally require the use of several grades of a conventional product. Normally the consistency grade of a product recommended for given applications will depend to some extent on the maximum temperature reached in the equipment requiring lubrication. Generally, harder products will be recommended when a high temperature is expected. This is because high temperature is normally associated with a softening of the grease in the equipment. In order to retain sufficient consistency for retention at high temperature, a product which is hard at normal temperature is required. In the case of the calcium complex grease, a soft consistency product can be used at any temperature to be encountered in service. This product then is not only multipurpose from the viewpoint of types of applications, but can also be considered to be a multigrade product.

The possibility of using a soft grade of product, with the assurance that the soft product still would be retained at the highest temperature likely to be encountered in service, provides an attendant advantage in low temperature dispensing characteristics. The calcium complex grease is softer at low temperature than is a conventional lithium multipurpose product. The softer product in turn would slump better in dispensing equipment and would dispense more easily than would the conventional multipurpose grease. Data are shown below:

Low Temperature — Consistency Characteristics

Lubricant	*NLGI Consistency Grade*	*Penetration mm/10* 77°F.	40°F.	20°F.	−20°F.
Ca Complex Grease	1	325	300	270	210
Conventional Li Multipurpose	2	285	240	200	175

The calcium complex grease also retains structure under the other types of conditions which it would encounter in multipurpose applications. It retains structure on extended shearing or working, resists water and retains oil as well as does a conventional lithium type multipurpose product. Actually, the structure retention characteristics are far better than the minimum required for the various applications in multipurpose service.

Two types of tests were used to examine the effect of shearing upon the consistency of the calcium complex grease. The conventional grease worker test using the fine hole worker plate for 10,000 double strokes showed that the grease broke down only slightly under these conditions and to about the same extent as the conventional lithium type product. A second test in which the grease is subjected to extremely high rates of shear of about 500,000 sec.$^{-1}$ by passing it at high pressure through a close clearance valve also showed that the grease did not break down. In fact, at high shear the grease actually hardened slightly. These data are shown in detail below:

Effect of Shearing on Consistency

Lubricant	*ASTM Pen. mm/10*	*Pen. After 10,000 Strokes mm/10*	*Pen. After High Shear Test*
Ca Complex Grease	325	330	300
Li Type M.P. Grease	285	290	285

Water also has little effect on these greases. Water washout tests in which a jet of water is directed against a rotating bearing containing the test grease showed that the water extracts very little grease from the bearing. Even boiling water has little effect on these products as shown by tests in which a small amount of grease was placed in a beaker containing

boiling water. The resistance to water is somewhat surprising in view of the fact that such large quantities of calcium acetate are used in the grease preparation. It is due in part to the fact that the thickener system is the inner phase of the dispersion and is protected by the water insoluble oil phase. It is also due in part to the fact that the calcium acetate does not exist as such in the dispersion, but rather exists as a complex with the higher molecular weight water-insoluble calcium salts. The data on water resistance properties of these greases follow:

Effect of Water on Structural Stability

Lubricant	*Water Wash-Out, % Loss** 77°F.	200°F.	*Solubility in Boiling Water—1 Hour*
Ca Complex Grease	0.5	0.5	None—no oil separation
Li Type Multipurpose Grease	0.5	0.25	Slight cloudiness — trace of oil separation

*Stream of water against housing of revolving anti-friction bearing.

The oil separation characteristics of these products are comparable with those of a conventional lithium multipurpose grease. One of the most severe requirements in regard to oil separation characteristics is resistance to oil separation under pressure such as might be encountered in centralized lubrication systems. These characteristics are measured in a laboratory test in which 50 grams of grease confined in a cylinder, the bottom of which is closed with a filter paper backed by a fine mesh screen, is subjected to a pressure of 100 psi for 22 hours. The amount of oil separated away from the grease at the end of that period is determined. The calcium complex grease is satisfactory in the test as shown below:

Pressure Oil Separation Characteristics

Lubricant	*Separation in 22 Hrs. 100 psi, %*
Ca Complex Grease	1.0
Li Multipurpose	3.0

Lubrication Ability

The lubrication characteristics of these complex greases are outstanding both in regard to the ability to lubricate under extreme pressure conditions and also in regard to lubrication life properties. In these respects they are far superior to the lithium type multipurpose products.

The ability to lubricate under heavy duty service has been measured in the laboratory both by Timken O.K. Load Test and by Four Ball Machine Test. The Four Ball Tests used for this work were the Mean Hertz Load Test and the Weld Point determination. These tests have been described by Nason.[3] Data on the calcium complex grease compared with the lithium multipurpose type product are shown below. It will be noted that the calcium grease is substantially better than the lithium type product in all of the various types of extreme pressure tests studied.

Extreme Pressure Properties

Grease	*Timken O.K. Loads, Lbs.*	*Four Ball Tests* *Mean Hertz Load, Kg.*	*Weld Point Kg.*
Ca Complex	45-55	50+	326
Li Type	<20	20	175

The anti-wear characteristics of these products also are excellent. These properties were determined in the Four Ball Test run under relatively mild conditions (steel vs. steel 10 kilogram load, one hour at 1800 RPM). In these tests the calcium complex type grease showed a much smaller wear scar diameter than did the lithium type multipurpose products shown below:

Anti-Wear Properties

Grease	*Four Ball Wear Scar Diameter (1800 RPM, 10 Kg. 75°C., 1 Hr.)*
Ca Complex	0.24
Li Type	0.50

The advantage of the calcium complex system for grease in preventing wear also shows up in friction oxidation type tests. In the 50 hour oscillating bearing test described by Morton and Paterson,[4] the calcium complex grease showed a remarkably low level of wear. This advantage in anti-freezing properties also showed up in a field test in heavy duty truck service where the calcium complex grease completely eliminated fretting corrosion in truck wheel spindles. Data are shown below:

Friction Oxidation Properties

Grease	*Iron Oxide Formation on Truck Wheel Spindles*	*Bearing Loss (Mg.) in 50 Hour Friction Oxidation Test*
Ca Complex	None	1.4
Li Type	Heavy	24.1

The demonstration that the thickener itself can serve as a load carrying agent as well as a thickener is the most important single factor extending the range of multipurpose products. Previously incorporation of extreme pressure characteristics into greases had required the use of reactive additives such as chlorine, sulfur, phosphorus or lead containing materials which introduced the possibility of high temperature corrosion and oxidation.

The lubrication life characteristics of the calcium complex greases also are outstanding. This characteristic was measured in a bearing life test in which a greased, 20-mm. shielded bearing is run at 10,000 RPM at 250°F. until failure. The test basically is a dynamic

oxidation resistance test as well as a lubrication test. The calcium complex greases run about three times as long as the conventional lithium multipurpose type product under these conditions.

Lubrication Life Characteristics

Grease	*Lubrication Life, Hrs. 10,000 RPM, 250°F., 20 MM Bearing*
Ca Complex	2100
Li Type Multipurpose	600

These data indicate that less frequent lubrication would be required with the calcium complex grease in shielded bearings operated at temperatures in the vicinity of 250°F.

C. *Field Experience*

The calcium complex grease has been used in a great variety of applications. Results confirm the laboratory indications that the range of uses which could be served by a single grease has been extended by the development of this product.

The grease was superior to lithium type products in automotive service. Passenger car ball joint wear was reduced an average of 39 per cent in comparison with lithium type grease. Quantitative steering torque measurements also showed that the calcium complex grease required less steering effort. As mentioned previously, fretting corrosion on heavy duty truck wheel spindles was essentially eliminated by this grease. Even in automotive service which is considered to be relatively mild, the calcium complex grease would have broader utility than lithium type products.

The grease has been used very extensively in general industrial applications. Its major advantage has been its improved lubrication life and its wider temperature range in comparison with the lithium type grease. It has successfully lubricated plain bearings, ball and roller bearings and small gears.

It has been used very successfully as a multipurpose grease in steel mills. Again, the high temperature advantage was apparent in applications such as crane bearings over ingot soaking pits. Its E.P. characteristics permitted it to be used freely throughout the plant in even the most heavily loaded bearings. It has been applied through conventional pressure guns and also through centralized lubrication systems.

Conclusions

A new calcium complex has been developed as a thickener for multipurpose grease having a greatly extended range of applications. This thickener is prepared from calcium acetate and calcium salts of higher molecular weight acids. The combined acids have a molecular weight of about 77. Greases prepared from this thickener show very little change in consistency between room temperature and 400°F. The thickener also has extreme pressure characteristics so that no reactive E.P. agent need be used. The excellent temperature consistency characteristics and inherent E.P. properties have extended the range of application for which a single grease can now be considered. Field tests have demonstrated that this single product can function successfully as a multipurpose grease for automotive, general industry, and metal rolling industry applications.

References

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3. Nason, D. K., NLGI Spokesman XV, No. 12, 22, (1952).
4. Morton, H. T. and Paterson, F. G., NLGI Spokesman XII, No. 5, 8 (1948).

J. J. Kolfenbach *graduated from Loras college with a BA degree in* 1939 *and received his PhD degree in biophysical chemistry from Iowa State college in* 1941. *He has been associated with Esso Research and Engineering company since* 1944. *He is presently section head of the industrial lubricants section. He is a member of ACS, Sigma Xi and SAE. A long-time contributor to the* NLGI Spokesman, *Mr. Kolfenbach is also a former chairman of the Technical Subcommittee on Fundamental Research.*

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A. J. Morway *received a BS degree in chemistry from the University of Florida and did graduate work at Columbia University and Brooklyn Polytechnic Institute. In* 1929 *he joined Esso Research and Engineering company, where he is now a senior research associate in the products research division. A prolific inventor, Mr. Morway was recently presented his* 200*th patent by the U. S. Commissioner of Patents. He invented some of the first premium quality anti-friction bearing greases, one of the first lithium-type aviation greases used during World War II and the newer calcium acetate multipurpose greases for industry and for automobiles, among other products.*

Literature and Patent Abstracts

Composition

Silicone Oil Grease Containing a Phthalocyanine and Acetylene Black

According to Sullivan, Baker and Singleterry, the stability of silicone fluids under service conditions of 400 to 500°F is increased if, in addition to a metal phthalocyanine, one to seven per cent by weight of a finely divided acetylene black is included in a lubricating grease containing such fluids. This particular black increases the resistance to gelation of the liquid polysiloxane. This use is described in U. S. Patent 2,929,779 which is assigned to the United States of America as represented by the Secretary of the Navy.

Such a lubricating grease can be prepared from the following, given in weight per cent: 20 chlorinated copper phthalocyanine; 3 acetylene black; 3 phenyl alpha naphthylamine; 1 phenylstearic acid; and 73 polyphenylmethylsiloxane of 50 cs. viscosity at 77°F. This forms a product which is useful for ball and roller bearings and has the ability to remain soft and oily at temperatures of 400 to 580°F.

Rapeseed Oil As a Component of Lubricating Grease

J. Grindrod, *Scientific Lubrication* (London) 12, No. 3, pp 21,24, March, 1960.

According to the author, hydrogenated rapeseed oil has been used in the manufacture of a batch of lithium base lubricating grease which is being subjected to field tests. Such use was encouraged by the Saskatchewan Research Council because rapeseed is being grown in the Canadian Prairie region.

The lubricant which is suggested for a multi-purpose grease is stated to be satisfactory over a temperature range of –10 to 300°F, water resistant, and to break not more than five points after 1,000 strokes in a grease-worker. Mention is made that the lubricating grease has not been tried in a CRC wheelbearing test.

Manufacturers of the rapeseed product hope to be able to replace hydrogenated castor oil and thus effect a saving in material costs.

Sodium-Aluminum Mixed Base Lubricating Greases

According to East German Patent 15,106, issued to Muller, aluminum soaps are made by converting alkali soaps using aluminum sulfate and the wet soap is dissolved in mineral oil to give a 25 per cent solution. One hundred kg. of this mixture was then added to 900 kg. of a sodium base lubricating grease. The resulting mixture had the same penetration but an improved resistance to water solution.

Silica Reaction Products As Grease Thickeners

According to Columbia-Southern Chemical Corp. (British Patent 820,548), the reaction product of finely divided silica and an isocyanate forms a satisfactory thickener for lubricating greases. Thus, 6.2 ml. of toluene isocyanate were added during fifteen minutes to 86.4 grams of Santocel ARD which had been dried in vacuum at 110°C for 24 hours. This mixture was then dried in an oven at 100°C for 40 hours.

When 10.7 grams of this product were mixed with 100 grams of solvent refined oil a high melting point, water resistant lubricating grease was formed with a worked penetration of 310.

Oil Dispersions of Calcium Acetate Hydrates

According to Morway (U. S. Patent 2,927,892, assigned to Esso Research & Engineering Co.), the monohydrate of calcium acetate forms stable dispersions in lubricating fluids whereas the anhydrous form tends to settle out upon storage. Dispersions of the dihydrate of calcium acetate tend to be more viscous than either the anhydrous or monohydrate. Likewise, the hydrates are said to have better antiwear and load-carrying ability than the anhydrous calcium acetate.

A base material was prepared by adding 58 weight per cent of a 100 SUS at 100°F mineral oil and 17 weight per cent of hydrated lime to a kettle and mixing to a smooth slurry. Then, without external heating, 25 weight per cent of glacial

acetic acid was gradually added taking care not to allow the temperature to rise above 200°F. After all the acetic acid was added, the mixture was allowed to cool to 150°F where it was stirred for one-half hour while maintaining this temperature by external heating to insure completion of the reaction. The mass was then passed through a Gaulin homogenizer operating at 6,000 psi. The product was an excellent smooth grease.

Twenty-five parts by weight of the above grease was mixed with 80 parts by weight of the 100 oil and homogenized twice to give a smooth fluid which had a viscosity of 186.7 SUS at 100°F but which gelled at 210°F. The stability after ten days storage at 80°F was excellent, and in a centrifuge test for 30 minutes at 1,500 rpm, 0.5 per cent precipitate was obtained. The fluid carried 14 weights on an Almen test and gave a scar diameter of 0.43 mm. in a 4-ball wear test at 1,800 rpm, 10 kg. load, for one hour at 75°C.

Fluid lubricants of the type described are said to be suitable for use in internal combustion engines and as textile mill lubricants. Also, because of their acid neutralization ability, they are useful for lubricating the upper cylinders of marine diesel engines operating on high-sulfur fuel oil.

The calcium acetate dihydrate is stable up to about 200°F and the monohydrate up to about 300°F.

Organosilicon Ureas As Lubricating Grease Thickeners

Pike in U. S. Patent 2,907,782, assigned to Union Carbide Corp., describes products obtained when aminoalkyl silicon compounds are treated with organic isocyanates. Certain of this class of materials are suitable for thickening silicone fluids to form lubricating greases.

For example, 13.1 grams of aminobutylmethylsiloxane cyclic tetramer dissolved in 50 ml. of toluene were treated with 10.5 grams of 1,5-naphthylene diisocyanate in 250 ml. of toluene by refluxing for one hour. The mixture was then cooled, filtered and washed with toluene before drying to give 22.2 grams of a white solid which did not melt at 300°C. This solid served as a grease thickener.

Composition and Process

Preparing Ureido Grease-Thickener Concentrate and Lubricating Greases Containing Same

A method is described by Traise, Hayne and Bunting in U. S. Patent 2,925,387 (assigned to Standard Oil Co., Indiana) for preparing a preformed oil-concentrate of the reaction product of a hydroabietyl amine and an organic polyisocyanate. This concentrate is then used to thicken lubricating fluids.

Thus, two solutions in lubricating oil are prepared; one containing 70 to 80 per cent of the hydroabietyl at a temperature of 70 to 100°F, and

the other containing 20 to 30 per cent of the organic polyisocyanate at a temperature of 150 to 250°F. The two solutions are separately introduced into a variable mixing chamber from which the mixture is discharged into the top of a spray tower. As the droplets of the reaction mixture fall through the tower, precipitation of the ureido compound occurs, followed by crystallization thereof. A granular solid which collects at the bottom of the tower has a temperature of 150 to 250°F.

In preparing a lubricating grease, 16 to 20 parts of the above concentrate were mixed with 10 to 18 parts of a solvent extracted SAE 10 oil and heated to 200°F where 65 to 70 parts of solvent refined SAE 40 oil were added to give a slurry. This fluid mixture was heated to 390 to 400°F, held at this temperature for 35 to 40 minutes, cooled to 200°F and passed through a colloid mill.

While the NLGI Grade of the resulting lubricating grease is not given, examples are cited of a product in which the thickener content was 8 per cent and which had a change in mechanical stability of 5 per cent and a dropping point of 480°F. In the case of another lot of lubricating greases, using the same raw materials, but in which the thickener was formed in situ rather than preformed, 7 per cent of the ureido compound gave the same characteristics as 8 per cent of the preformed compound.

Characteristics

Various Investigations of Lubricating Greases in USSR

The No. 7, 1958 issue of Trudy Vsesopuz. Nauch.-Issledovatel, Inst. po Pererabotke Nefti i Gaza i Poluchen Zhidkogo Topliva contains several articles dealing with investigations of lubricating greases.

In an investigation of "Thixotropic Properties of Calcium Base Lubricating Greases," Volchinskaya, Sentyurikhina and Oparino, p. 374-8, concluded that the thixotropic properties of the thickened lubricants did not depend upon the oil used. The minimum thixotrophy

was obtained when the thickener consisted of 16 per cent of calcium soap of high molecular weight fatty acids and one per cent of water-soluble salts of low molecular weight fatty acids.

Using Georgian clay, bentonite type thickeners for oils were investigated by Kruglyi, Makeeva, Veisman and Mikhailova (p. 378-89). It was found that only 10 to 15 per cent of the clay base thickeners was required to give lubricants comparable with similar products containing 14 to 18 per cent soaps made from fatty acids.

An article by Sentyurikhina and Oparina (p. 403-9) deals with "Molybdenum Disulfide" as a lubricant. Both dry and bonded coatings were tested, but no mention was made of use in lubricating greases.

"Storage Characteristics of Lubricating Greases" were studied by Martynov, Kaulina and Kochkova (p. 433-48), using two products designated as Tsiatim-201 and -221. Oil separation up to 20 per cent over considerable periods was thought to be unimportant. The viscosity of the products increased with age as did the acidity probably due to oxidation. Humidity also played a part in the changes observed.

Predicting Grease Performance From Capillary Viscometry Data
J. G. Savins, *Lubrication Engineering*, 16, No. 3, March, 1960, p. 108-9.

Consideration of a previously published article (Miller, Walsh and Slaymaker, "Effect of Capillary Length to Diameter Ratio on Grease Viscosity," *Lubrication Engineering*, June 1958) explains the difference in viscosity found with varying lengths of capillary as due to correction for "end-effects."

Savins suggests a method of utilizing such corrections and thus predicting the performance of lubricating greases in centralized lubricating systems.

Application

Mobile Lubrication Equipment
***Lubrication* (Texaco Inc.) March, 1960.**

Portable lubricating equipment is described for use in industry, the construction field or on the farm and, in most cases, the illustrations of grease guns indicate mechanical action.

Mention is made (p. 35) that multi-purpose grease has helped to simplify lubrication because such a product has replaced several specialty greases and often provides superior lubrication.

Compact Cars

The April, 1960 issue of *Lubrication* (Texaco Inc.) discusses the design features and lubrication requirements of American compact cars.

In general, the same types of gear lubricants and lubricating greases as are used in larger cars are also satisfactory in the smaller models. A tabulation gives the car manufacturers recommendations for transmission and differential lubricants.

After giving details of the suspension systems used in the various cars, it is stated: "All of the suspension systems include points which

see following page

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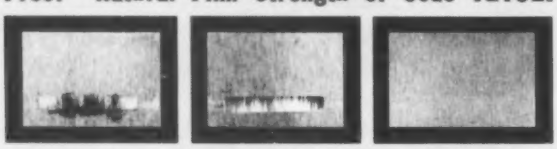

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must be periodically lubricated. This is particularly true of the ball joint units used to connect the front suspension system components." The importance of periodic lubrication of chassis points and the frequent neglect of this point is stressed by indicating the possibility of wear and resulting repair bills when the supply of lubricating grease is depleted.

Finally, mention is made that good multipurpose lubricating greases are available which are satisfactory for chassis, wheel bearings, water pumps, etc., on the compact cars.

Bulk Shipments of Lubricating Greases
***Petroleum Week*, March 18, 1960, p. 21**

A news item indicates that Cities Service Oil Co. has developed a new bulk grease-delivery method that "paves the way for substantial savings in over-all lubrication costs." The company uses a tractor-trailer unit with two vertical cylindrical containers, each capable of holding 12,000 pounds of grease. Both containers can be unloaded into the customer's central storage tanks, designed for the purpose, in about an hour. Previously, the lubricant was shipped in 400-pound drums, which were stored until needed. The new method eliminates time-consuming and expensive handling of individual drums and makes possible substantial savings in customers' storage space, according to Cities Service.

The Literature and Patent Abstracts column is written for NLGI by C. J. Boner, director of laboratories for Battenfeld Grease and Oil of Kansas City, Missouri.

Books

***Petroleum Products Handbook*, McGraw-Hill Book Co., 864 pages, Virgil B. Guthrie, Editor.**

Over thirty specialists have contributed seventeen chapters dealing with various petroleum products.

Chapter nine is devoted to "Lubricating Oils and Greases" and is 141 pages in length. The portion of this chapter dealing with "Lubricating Greases" is 48 pages in length and is contributed by C. J. Boner.

Tests

The Behavior of Fuels and Lubricants In Dynamic Test Equipment Operating In the Presence of Gamma Radiation by M. E. Krasnow, O. P. Reynolds and O. C. Wolford, Inland Testing Laboratory.
PB 161127, 182 pages and 12 references. Obtainable from OTS $3.00.

In addition to other products, four lubricating greases were investigated.

Processing

Developments in Production of Lubricating Grease
J. Grindrod, *Scientific Lubrication*, 12, No. 3, pp 18-20, March, 1960.

A general review of equipment and processing for the manufacture of lubricating greases is given.

In addition, mention is made of the classes of ingredients used in such manufacture and also a table is included giving some of the characteristics of different types of lubricating greases.

People in the Industry

Schubert Elected President of Emery

A. W. Schubert has been elected president of Emery Industries, Inc., succeeding John J. Emery who takes over the newly-created post of chairman of the board. Mr. Schubert formerly was executive vice-president.

The company announced that "stockholders approved the recommendations of the board of directors calling for establishment of two offices to carry out the increasing responsibilities brought on by the several expansions of recent years."

Foote Mineral Promotes Eldon

William A. C. Eldon has been named operations manager of Foote Mineral company's Cold River, N. H., plant, it was announced by Felix B. Shay, vice-president, production and engineering. Eldon has been with Foote Mineral since 1950 and has served at the company's Exton, Pa., and Kings Mountain, N. C., plants in an engineering capacity. For the past two years he has been project engineer in Foote's central engineering department. He replaces William R. Hudspeth, Jr., who has been named special projects manager of the company's marketing department, and will be headquartered in Philadelphia.

ASLE Honors Two

Two lubrication experts were honored at the 15th Annual Meeting of the American Society of Lubrication Engineers, held at Cincinnati in April. Given the Captain Alfred E. Hunt memorial award for their paper "Viscoelastic Behavior of Greases," chosen as the best ASLE paper presented during the year, were E. O. Forster and J. J. Kolfenbach—both of Esso Research and Engineering.

Kolfenbach has authored a number of papers for NLGI and before a change of company responsibilities necessitated his withdrawal, was NLGI subcommittee chairman for fundamental research. He organized the first technical research symposium at an NLGI annual meeting in Chicago, 1958.

Forster has been a frequent contributor to the NLGI SPOKESMAN and has been active in Institute affairs. He is presently vice-chairman of the subcommittee for fundamental research.

Pure Changes Scientific Research Titles

A revised system of personnel progression and titles, giving formal recognition to the contributions of scientists and technical specialists in non-administrative positions, was announced at the Pure Oil company's research center by Hugh L. Hemmingway, director of research.

Professional personnel at the center can progress on a merit basis to positions of increased responsibility by one of three routes: the supervisory or administrative route, the scientific route, and the technical specialist route.

In the supervisory route, the top positions in ascending order are: 1) group supervisor; 2) section supervisor; 3) division director; 4) assistant director of research or assistant manager of the research center, and 5) director of research or manager of the research center.

Parallel positions on the scientific route are: 1) research scientist; 2) senior research scientist; 3) research associate; 4) senior research associate, and 5) research consultant. For technical specialists the top jobs are: 1) technologist; 2) senior technologist; 3) technical specialist; 4)

senior technical specialist, and 5) technical consultant.

Mr. Hemmingway announced the appointment of Dr. George W. Ayres as senior research associate, the highest nomination thus far on the scientific route and equivalent to the position of assistant director of research.

Pure Announces Marketing Promotions

Three top promotions in the Pure Oil Company's marketing division have been announced by Harry L. Moir, vice-president for retail marketing.

Effective August 1, Floyd W. Bules became general manager of retail marketing, a position formerly held by Mr. Moir in addition to his duties as vice-president. Frank H. Allen succeeds Mr. Bules as assistant general manager, and Joseph H. Askren, manager of Pure's Northeastern marketing division with headquarters in Detroit, comes to Chicago to become regional general manager for northern marketing operations.

Harry D. Armitage Retires from Emery

Harry D. Armitage, manager of the New York office of Emery Industries, Inc., retired recently after 35 years of sales in the New York area.

Climaxing his outstanding career, he was presented with the distinguished salesmen's award of the Cincinnati Sales Executives council at their award dinner on May 11. He was the guest at a banquet held in his honor by his fellow workers in Cincinnati, at which he was presented with a silver cigarette dish.

Although Mr. Armitage originally joined Emery on May 1, 1925, as a member of the purchasing department, he shortly thereafter transferred to the sales department. In September he moved to the company's New York office, which he has made his headquarters ever since.

He has been a major factor in Emery's growth to its present position in the New York area, from a beginning of five regular customers in 1925.

Rheem Division Names Gautreaux

J. B. Gautreaux has been appointed resident plant manager of Rheem Manufacturing company's container division plant at New Orleans, according to E. F. Paquette, division vice-president and general manager. Mr. Gautreaux succeeds Louis A. Reber, who died June 14.

Mr. Gautreaux was born near Houma, La. He entered the steel container industry in New Orleans in 1931 and was associated with Mr. Reber in the founding in 1933 of Southern Steel Barrel company, acquired by Rheem in 1938.

Mr. Gautreaux has been associated with Rheem since then in various supervisory capacities. He was superintendent of ordnance production during World War II, served two years as works manager of the Rheem plant at Houston, Tex., and was named works manager at New Orleans in 1952.

J. L. Keefe Joins American Potash

Joseph L. Keefe has joined American Potash & Chemical Corp. as a market development representative, it was announced by Dr. Howard E. Kremers, district manager of market development in New York.

Keefe, who will headquarter at the company's New York offices, was active for seven years in sales work with Texas-U. S. Chemical Co. and with U. S. Testing Co.

Burdon Is New District Sales Manager

Mr. Joseph H. Bennis, sales manager of New York & New Jersey Lubricant Co., Inc., New York, announces that Kenneth Burdon has been named Southern New England district sales manager. He succeeds Harry H. Beaman who retired after 32 years with the company.

Industry News

California Battenfeld Completes New Control And Lab Facilities

Battenfeld Grease & Oil Corp. (Calif.), 19530 South Alameda, Compton, California, is proud to announce the completion of an extensive addition to its lubricating grease control and research laboratory.

Increased through-put in the production department has hastened the expansion of the laboratory. The floor space occupied by this important segment of the corporation has recently been more than doubled. A number of new testing facilities have been added, including an apparent viscosity (minus 65°F) cabinet, pressure bleed and evaporation cells, plus extreme pressure and stability testing machines.

THIS new and improved laboratory is part of the complex recently completed by Battenfeld of California, at Compton . . . a firm which started in 1954.

The physical improvements, combined with the addition of added experienced personnel, allow the company to aggressively continue the close product control and new product development which is such an important part of its success.

H. E. Hale, chief chemist, states, "The completion of this part of our expansion program marks the accomplishment of a major phase of company planning. We are now more than ever fully equipped to maintain strict control of the hundreds of lubricating greases manufactured in the plant. Our new lab also affords us greater opportunity than ever before in the fields of research and development."

Battenfeld of California was established in 1954. Today the laboratory boasts four highly-trained chemists under the direction of Mr. Hale.

The activities of the technical group are closely coordinated with the extensive laboratory facilities operated by the parent company in Wichita and Kansas City, Missouri. Battenfeld (Calif.) is a subsidiary of Southwest Grease & Oil Company, Inc., Wichita, Kansas.

Elco Bulletin Discusses Industrial Lubricants

Lube/Report No. 102, "Performance of SCL Industrial Lubricants," is the title of a new bulletin published by the Elco Lubricant Corporation. The 12-page report presents detailed information on the factors involved in the selection and use of lubricants for industrial plant machinery.

Featured is a comprehensive case study of the use of SCL-type lubricants in four steel plants. After 22 years, the lubricant performance record is reported as perfect—not a single gear failure due to breakdown of the lubricant. The lubrication practices and properties of SCL lubricants which produced this record are described.

This bulletin will be valuable to all industrial plant personnel responsible for the selection of lubricants or the maintenance of machinery.

Copies of Lube/Report No. 102 may be obtained from Elco, Jennings Rd. & Denison Ave., Cleveland 9, Ohio.

New Spray System Announced by Farval

An innovation in spray lubricating industrial gearing has been announced by Farval division, Eaton Manufacturing company. Where frequency of lubricating single, heavy-duty gears is no problem but inaccessibility presents a danger to maintenance personnel, this new, versatile spray system offers an inexpensive, efficient method of lubrication.

Dependability of the new spray system is pointed to by the simplicity of its operating principles. With a hand grease gun attached to a conveniently located fitting, lubricant will be sprayed as long as pumping is continued. Lubricant pressure forces down a spring-loaded piston, opening porting to the Farval spray control valve. This allows air and lubricant, each under its separate pressure, to be forced through the spray nozzle. When lubricant flow ceases, the piston returns to its original position, closing the ports. The air supply is then shut off, limiting compressed air consumption to the amount needed for each delivery of oil or grease.

Dry Lubricant Stick Offered by Alpha-Molykote

Extreme-pressure molybdenum disulfide dry lubricant in stick form is now available from the Alpha-Molykote Corp. Resin bonded for greater strength, the Molykote lubricating stick permits easy application of a lubricating film to cutting and shaping tools, sliding areas of small and medium size machine parts, or wherever metallic dry friction occurs on sliding surfaces. Application is simple. The stick is just rubbed firmly over the cleaned surface.

The Molykote lubricating stick has been used to considerable advantage in Europe on metal cutting tools such as taps, dies, gear shapers, planers and milling cutters, where no cutting fluid is employed. Also on tools and paper cutting blades. With proper application the life of the cutting tool is frequently doubled, or more. Cutting tools rubbed with the stick produce clean cuts, low cutting temperatures, show less tendency to build up on edges and stay sharp longer.

Molykote lubricating sticks have also proved to be useful on small surfaces where oil cannot be used because of contamination, temperature restrictions, etc., as on small

parts of precision mechanisms, optical instruments and automation equipment. Because of its physical strength, the stick can even be formed in any desired size for use as an element in the bearings of small machines, ways and light equipment undergoing oscillating movements.

Molykote lubricating sticks are available in slide boxes containing five or ten sticks. Additional information may be obtained by writing to the Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Chek-Chart Publishes Two 1960 Lubrication Guides

The Chek-Chart Corp., 33 East Congress Pkwy., Chicago, Ill., has announced the publication of the 1960 edition of its Truck Lubrication guide and a new Farm Tractor Lubrication guide.

Containing 112 pages of factory-approved truck lubrication information, the Truck Lubrication guide covers all popular standard production truck models for a ten-year period from 1951 through 1960. It also covers axle, semi-trailer and trailer units; specially-assembled, heavy-duty and special-purpose trucks; and school buses and motor coaches. An essential truck maintenance tool, the guide lists the recommended lubricant, point of application and service interval—organizing truck lubrication service into a planned and orderly procedure which saves time and assures complete truck lubrication.

The 64-page Farm Tractor Lubrication guide gives manufacturer-approved lubrication information on all popular makes and models of farm tractors. Two tabular pages list the motor oil and gear lubricant recommendations and capacities for the crankcase, transmission and final drive units for crawler tractors. Five pages of service instructions provide complete service information on all phases of tractor lubrication.

Complete information and prices are available from Chek-Chart.

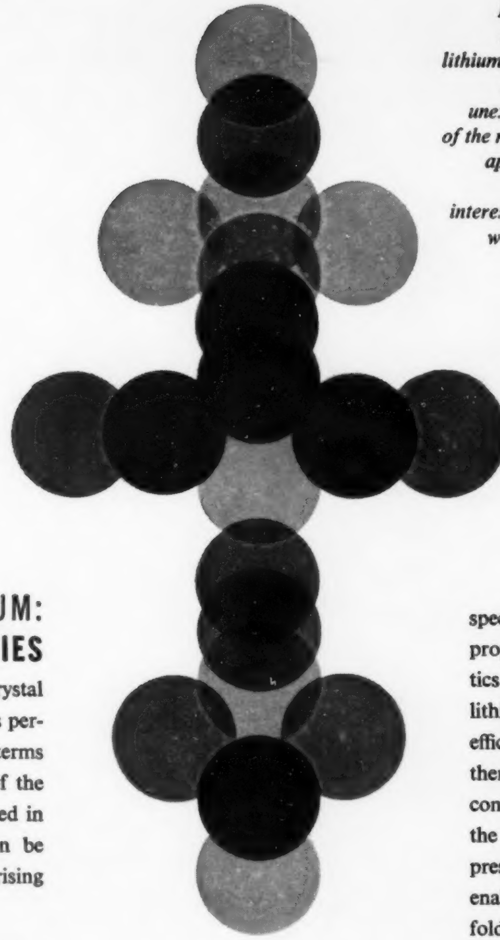
Pre-Sell the Customer

Compounding charms in advance is the approach Bel-Ray Co., Farmingdale, N. J., manufacturer of special lubricants, is taking to introduce three new gear compounds to users of the type of heavy equipment for which the lubricants were perfected.

Specifically the approach is a brilliantly-colored flyer in orange and black personalized by a memo each sales representative directs to each of his own customers by name. This flyer flashing news of the new gear compounds teases customer interest by citing four major reasons why the new compounds are more desirable than other lubricants. The reasons are facts proven in gruelling tests made on heavy equipment similar to the customer's and conditions of testing and results are given on the flyer. So, even before the sales representative gets to his customer orally, the customer is primed and waiting with four big reasons for wanting to try the new Bel-Ray compounds. . . namely their noise reducing, no-fling, impenetrable qualities.

These three new compounds are available in two types each, for hand applications and for spray applications. The Molylube open gear compound is for heavily loaded open and semi-open gears; the Molylube gear-kote compound is for heavily loaded open type gears; the B-R geartex compound is to protect gears from "feathering" in abnormal shock loads. All are available all over the country from Bel-Ray sales offices in Seattle, Washington; Birmingham, Alabama; Atlanta, Georgia and Pittsburgh, Pennsylvania, as well as at Farmingdale, New Jersey.

In lithium's differences lie its greatest strengths. Nominally an alkali metal, lithium does not always act like its Group IA neighbors . . . earning it the tag, "the unexpected element." The gratifying fact of the matter is that lithium's most promising applications reflect its most unexpected properties. A number of the more interesting properties, all of them concerned with the solid state, are discussed here.



THE CASE FOR LITHIUM: SOLID STATE PROPERTIES

The wide range of ionic or crystal radii displayed by the alkali metals permits their nominal classification in terms of other cations for which each of the alkali metal ions may be substituted in crystal lattices. Thus, lithium can be associated with 21 elements comprising small crystal ions.

Mg^{2+}, Al^{3+}, Ga^{3+}, Cr^{3+}, V^{3+}, Ti^{4+}, Fe^{3+}, Ge^{4+}, Mo^{6+}, W^{6+}, Ni^{2+}, Co^{2+}, Fe^{2+}, Zn^{2+}, Sc^{3+}, In^{3+}, Zr^{4+}, Hf^{4+}, Sn^{4+}, Nb^{5+}, Ta^{5+}

By comparison, the larger sodium, potassium, rubidium and cesium ions can replace few other cations without materially distorting or disturbing the existing arrangement of lattice units. This size factor . . . plus the ability of lithium ions to aid in stabilizing ions of higher valence state in a host crystal . . . is responsible for the interesting catalytic or semiconductor properties common to mixed lithium oxide—transition metal oxide systems.

Oxides of the type:
$(Li_x M^{2+}_{1-2x} M_x^{3+}) O$ or $Li_x M_{1-x} O$,
where M is Mn, Fe, Co, or Ni, are p-type controlled impurity semiconductors of high electrical conductivity.

METALLURGY A small atom, plus high electronegativity permits lithium alone of all the alkali metals to be incorporated as a beneficial alloying constituent of numerous metals, including Mg, Cd, Al, Be, and Ag. In general, the lithium alloys of these metals exhibit increased strength and better working properties than the base material. One good example is the increased strength at higher operating temperatures of new aluminum-lithium alloy 2020. Lead-lithium alloys also have higher tensile strength than pure lead. By taking advantage of the excellent neutron absorption properties of the lithium-6 isotope, these alloys can be fabricated into excellent shields against thermal neutrons and gamma radiation.

CERAMICS The inclusion of lithium in glasses and glazes yields more condensed and compact structures with decreased thermal expansion and increased stability. It is still difficult to point to the specific atomic, molecular, and ionic properties on which these characteristics depend. But the growing use of lithium in ceramics with a very low coefficient of thermal expansion and high thermal shock resistance is being accompanied by increasing research into the physical chemistry of lithium. The presence of lithium in a glass structure enables the alumina ion to attain fourfold coordination, thus serving as a glass former. And lithium's small ionic radius permits a lithium ion coupled with an aluminum ion to displace two magnesium ions in the spinel structure.

MORE TO COME: The tale of lithium is neither easily nor quickly told. The material presented here constitutes the briefest of introductions. But if it has whet your appetite, we can happily provide you with more of the same—long on facts and ideas, short on flim-flam, and complete with derivations and references. Just write for a copy of "Lithium vs. The Other Alkali Metals". Foote Mineral Company, 402 18 West Chelten Building, Philadelphia 44, Pennsylvania.

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